IN THE UNTED STATES PATENT AND TRADE MARK OFFICE

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APPLICATION NO.:   10/603,689

FILING DATE: June 26, 2003

GROUP ART UNIT: 1756

EXAMINER: Saleha R. Mohamedulla

TITLE: EXPOSURE   METHOD,   MASK   FABRICATION   METHOD,
                     FABRICATION   METHOD   OF   SEMICONDUCTOR   DEVICE,
                     AND EXPOSURE APPARATUS

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SIR;

CERTIFIED TRANSLATION

    I, Kaoru TASAKA, am an official translator of the Japanese
language into the English language and I hereby certify that the
attached comprises an accurate translation into English of Japanese
Application No. 2002-189086, filed on June 28, 2002.

    I hereby declare that all statements made herein of my own
knowledge are true and that all statement made on information and
belief are believed to be true; and further that these statements
were made with the knowledge that willful false statements and the
like so made are punishable by fine or imprisonment or both, under
Section 1001 of Title 18 of the United States Code and that such
willful false statements may jeopardize the validity of the
application or any patent issued thereon.

___June 8, 2006___   _____

Date   Kaoru TASAKA

[Name of the Document]   Application for Patent

[Reference Number]   0290137603

[Application Date]   June 28, 2002

[Destination]   Commissioner, Patent Office of Japan

5 [International Patent Classification]   H01L 21/027

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[Designation of Charge]

20   [Ledger No. of Prepayment]   007364

    [Amount of Payment]   21,000

[List of the Documents]

    [Object Name]   Specification   1

    [Object Name]   Drawing   1

25   [Object Name]   Abstract   1

    [No. of General Power of Attorney]   9904452

    [Necessity of Confirmation]   Necessary

[Name of the Document]   SPECIFICATION

[Title of the Invention]   EXPOSURE METHOD, MASK FABRICATION METHOD, AND FABRICATION METHOD OF SEMICONDUCTOR DEVICE

5   [WHAT IS CLAIMED IS:]

[Claim 1]

An exposure method for transferring a desired pattern on an exposure target utilizing a reflective mask for an extreme ultra violet ray, characterized by

10   comprising the steps of:

providing respective reflective mask each having a mask pattern consisting of only pattern forming elements of the same direction by dividing pattern forming elements of the mask pattern corresponding to said

15   desired pattern relative to a projection vector of said extreme ultra violet ray;

sequentially carrying out a pattern transfer on said exposure target by irradiating said extreme ultra violet ray and a reflection light thereof with regard to

20   respective reflective mask in the respective direction; and

rotating, at the time when one reflective mask is changed to the other reflective mask, said other reflective mask and said exposure target so that an angle

25   of the pattern forming elements of said other reflective mask and the projection vector becomes equal to an angle of the pattern forming elements of said one reflective mask and the projection vector.

[Claim 2]

30   The exposure method as claimed in Claim 1, characterized in that:

said reflective mask of the respective direction includes a V-line mask in which a pattern only including the pattern forming elements perpendicular to said projection vector is formed, and an H-line mask in which
5   a pattern only including the pattern forming elements horizontal to said projection vector is formed.
[Claim 3]

A mask fabrication method for transferring a desired pattern on an exposure target utilizing a reflective mask
10   for an extreme ultra violet ray, characterized by comprising the steps of:

dividing pattern forming elements of a mask pattern corresponding to said desired pattern with regard to respective direction relative to a projection vector of
15   said extreme ultra violet ray;

forming respective reflective mask each having a mask pattern consisting only of pattern forming elements of the same direction with regard to the respective direction; and

20   configuring respective reflective mask of respective direction so that when the reflective mask and said exposure target are rotated relative to said projection vector, an angle of the pattern forming elements of respective reflective mask and the projection vector is
25   always the same.
[Claim 4]

The mask fabrication method as claimed in Claim 3, characterized in that:

said reflective mask of the respective direction
30   includes a V-line mask in which a mask pattern only including the pattern forming elements perpendicular to

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said projection vector is formed, and an H-line mask in which a mask pattern only including the pattern forming elements horizontal to said projection vector is formed.

[Claim 5]

5   A fabrication method of a semiconductor device including a lithography process for transferring a desired pattern on an exposure target using a reflective mask for an extreme ultra violet ray, characterized by comprising the steps of:

10   providing respective reflective mask each having a mask pattern consisting only of pattern forming elements of the same direction with regard to the respective direction by dividing pattern forming elements of the mask pattern corresponding to said desired pattern

15   relative to a projection vector of the extreme ultra violet ray;

sequentially carrying out transfer of said mask pattern on said exposure target by irradiating said extreme ultra violet ray and its reflection light with

20   regard to respective reflective mask in the respective direction; and

rotating, at the time when one reflective mask is changed to the other reflective mask, said other reflective mask and said exposure target so that an angle

25   of the pattern forming elements of said other reflective mask and the projection vector becomes equal to an angle of the pattern forming elements of said one reflective mask and the projection vector.

[Claim 6]

30   The fabrication method of a semiconductor device as claimed in Claim 5, characterized in that:

said reflective mask of the respective direction includes a V-line mask in which a mask pattern only including the pattern forming elements perpendicular to said projection vector is formed, and an H-line mask in

5   which a mask pattern only including the pattern forming elements horizontal to said projection vector is formed.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field to which the Invention Pertains]

10   The present invention relates to an exposure method used in a lithography process for forming a circuit pattern of a semiconductor device, a mask fabrication method of an exposure mask used in this lithography process, a fabrication method of a semiconductor device

15   including the lithography process, and in particular, to an exposure method using a reflective mask adaptable to a so-called extreme ultra violet ray, a fabrication method of the mask and a fabrication method of a semiconductor device.

20   [0002]

[Prior Art]

        In a lithography process that is one of processes for fabricating a semiconductor device, a wave-length of a light source in an exposure apparatus tends to be

25   shorter along with the miniaturization of forming pattern. For example, the light source has been changed from an i-ray (wave-length = 365 nm) to a KrF Excimer (wave-length = 248 nm), to an ArF Excimer (1 wave-length = 93 nm), and to an F2 (1 wave-length = 53 nm). This means that in

30   order to principally improve the resolution, it is performed by the increase of a numerical aperture (NA) of

a projection optical system and the shortened wave-length of the exposure light. Generally, it is well-known that the resolution determined by the wave-length of an exposure light is expressed by the Rayleigh's formula as

5   $w = K1 \times (\lambda / NA)$, wherein w is a resolution of a pattern, NA is a numerical aperture of the projection optical system, and λ is a wave-length of the exposure light. Further, K1 is a positive constant of 1 or less determined by the resist and the process used in the

10 exposure process.
    [0003]

       Further, it has recently been proposed to use a so-called Extreme Ultra Violet ray (EUV) such as a light of a soft X-ray region having a wave-length of 5 to 15 nm as

15 the exposure light in order to cope with further miniaturization of a pattern. In a case where the EUV ray is employed, the resolution $w = 43$ nm is obtained from the above-mentioned Rayleigh's formula, provided that the K1 = 0.8, the NA= 0.25, and the wave-length of

20 the EUV ray as the exposure light is 13.5 nm. Then, it becomes possible to carry out the process of the pattern that is compliant with a design rule for 50 nm pattern width. To that end, the EUV exposure technology is expected to be a future exposure technology as a possible

25 candidate.
    [0004]

       However, regarding the EUV ray, there is not any material (substance) that does not absorb but does transmit the EUV ray, so that it is impossible, for the

30 EUV ray, to configure a light transmission type projection optical system that is widely applied in a

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conventional lithography process. Accordingly, it is
necessary to configure a reflection type projection
optical system (including a reflective mask and a
reflection type optical system for reflecting a light) in
5   a case of using the EUV ray.
[0005]
    Fig. 3 is a schematic diagram showing one example of
an exposure apparatus constituting a reflection type
projection optical system. The exposure apparatus in Fig.
10   3 includes a light source 1 for the EUV ray, a reflective
mask 2 and a reflection type optical system 3 (plural
reflection mirrors, for example), a mask holder 4 for
holding the reflective mask 2, a movable reticle stage 5,
a wafer holder 6, and a movable wafer stage 7. A wafer 8
15   as an exposure target is to be held on the movable wafer
stage 7 by way of the wafer holder 6. As the light
source 1 for the EUV ray, a laser plasma system may be
exemplified, in which a high power laser light such as
the Excimer laser and the like is focused and irradiated
20   on the EUV ray radiating material such as rare gas
spouting from a not-shown nozzle, and generates the EUV
ray upon transiting to a low potential condition so that
the material is excited to be in plasma state. And the
EUV ray irradiated from the light source 1 passes through
25   the reflective mask 2 and the reflection type optical
system 3, thereby the pattern (the mask pattern) formed
on the reflection plane of the reflective mask 2 is
transferred on the wafer 8 as an LSI pattern (circuit
pattern that is necessary for configuration of the
30   semiconductor device). In this case, an illuminated area
on the reflective mask 2 is formed in a ring shape, and

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further, a scanning exposure system is employed, in which
the pattern on the reflective mask 2 is sequentially
transferred on the wafer 8 by scanning the reflective
mask 2 and the wafer 8 relatively to the reflection type
5   optical system 3.
[0006]

Fig. 4 is a perspective view showing a structural
example of the reflective mask 2 used in the exposure
apparatus. As shown in this figure, it is known such
10   mask that is equipped with a mask blank 2a for reflecting
the EUV ray and an EUV ray absorption film 2b formed so
as to cover the reflection plane of the mask blank 2a.
The mask blank 2a has a multi-layered film structure
formed by alternately stacking a Mo (Molybdenum) film and
15   a Si (Silicon) film, and the repetition number of the
stacks is usually 40. By the multi-layered film
structure as described above, the mask blank 2a reflects
the EUV ray having 13.5 nm in wave-length at reflectivity
of approximately 70%. Further, by covering the
20   reflection plane of the mask blank 2a with the absorption
film 2b having corresponding pattern thereof, the
reflection of the EUV ray is selectively carried out. It
is noted that, if the reflection material such as multi-
layered film is carried out the patterning to the
25   absorption film blank, the recovery upon failure is
impossible, but if the patterning is carried out by
providing such absorption film 2b, it becomes possible to
try again and becomes easy to repair the pattern, so that
it is preferable to cover the mask blank 2a with the
30   absorption film 2b.
[0007]

In a case of using such reflective mask 2, the light reflected at the reflection plane has to be introduced to the reflection type optical system 3 without mutually interfering with the incident light to the reflection

5   plane. Accordingly, the incident light to the reflective mask 2 has to be a skewed incident light having an incident angle θ relative to a normal line of the reflection plane. The incident angle θ of the incident light is determined by the NA of illumination

10   (hereinafter referred to as an NAill) at the reflection plane, and this is determined by the NA at a wafer surface of a reflective type projection optical system and a magnification of projection based on a desired resolution. For example, provided that the magnification

15   of projection is 4 times system taking over the magnification of projection of a conventional exposure apparatus, the incident angle θ of the incident light to the reflective mask 2 becomes around 4 degrees when the level of the NA = 0.2 to 0.3 determined by the desired

20   resolution.

[0008]

[Problem to be solved by the Invention]

However, in a case of the skewed incidence as described above, the pattern width transferred on the

25   wafer 8 fluctuates depending on the direction of the mask pattern on the reflective mask 2 relative to the projection vector of the incident light.

[0009]

In this case, if the mask pattern is for

30   transferring the LSI pattern, for example, the direction of the mask pattern is divided by whether the mask

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pattern is parallel or perpendicular relative to the
direction of the projection vector of the EUV ray. In
other words, the mask pattern for transferring the LSI
pattern is normally able to be divided into pattern

5   forming elements having sides parallel to the direction
of the projection vector and pattern forming elements
having sides orthogonal to the direction of the
projection vector. Accordingly, each pattern forming
elements constituting the mask pattern is defined as

10 described herein after in the text.
[0010]

    Fig. 5 is a conceptual diagram for explaining the
direction of the mask pattern. As shown in the figure,
the mask pattern formed on the reflective mask 2 is

15 scanned in the Y direction in the figure as the movable
reticle stage 5 moves (see Fig. 3), and thereby, the mask
pattern is transferred on the wafer 8. The incident
angle θ (4 degrees, for example) of the EUV ray incoming
askew at this time is the angle around the X axis in the

20 figure. Accordingly, the pattern forming elements
extending in the direction parallel to the scanning
direction of the mask pattern, namely the pattern forming
elements having sides parallel to the direction of the
projection vector are defined as a V-line (Vertical-line).

25 On the contrary, the pattern forming elements extending
in the direction perpendicular to the scanning direction
of the mask pattern, namely the pattern forming elements
having sides orthogonal the direction of the projection
vector are defined as an H-line (Horizontal-line).

30 [0011]

    Fig. 6 is an explanatory view for showing one

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specific example obtained by simulating the difference of the pattern width of the V-line and the H-line after pattern transfer in the case of the EUV ray incident askew. Generally, in a case of strictly simulating the difference of the pattern width of the V-line and the H-line, it is necessary to introduce a three-dimensional electromagnetic field simulation in consideration of the thickness of the absorption film 2b (Fig. 4) on the reflective mask 2, but in the figure, it is approached by the case where the EUV ray incident on a two dimensional binary mask, provided that the thickness of the absorption film 2b is zero. In the result of the simulation depicted in Fig. 6, the transferred line width of a line and a space of every V-line and H-line on the wafer 8 is calculated under the condition where the wavelength of the EUV ray = 13.5 nm, the NA = 0.25, the σ = 0.70, the incident angle on the mask = 4 degrees (around X axis), the magnification of projection is 4, and the pattern width of the line and the space on the wafer = 50 nm. According to the simulation result, it is recognized that there is the line width difference of around 4 nm between the V-line and the H-line in the range of the focus range of ± 0.1 μm. Further, it is recognized that the fluctuation of the V-line and the H-line within the focus range is around twice thereof.

[0012]

As described above, in the case of the EUV ray incident askew on the reflective mask 2, the width of the line pattern transferred on the wafer 8 is fluctuated depending on the direction of the mask pattern relative to the projection vector, and as a result, it is probable

to cause an adverse effect to the resolution of the transferred image. However, various technologies have been conventionally proposed regarding the correction for removing the width difference between the V-line and the

5 H-line, but the technology for improving the margin difference of the resolution depending on the incident angle of the EUV ray upon exposure process which causes fluctuation in the width difference between the V-line and the H-line is not particularly proposed. Further,

10 the width of the transferred pattern also depends on the repetition rate (pitch) or the crude density of the pattern on the reflective mask 2 (herein after, this is called as an OPE (Optical Proximity Effect) characteristic), and this OPE characteristic also

15 fluctuates depending on the incident angle of the EUV ray.
[0013]

According to the present invention, it is so arranged not to cause the difference of the pattern width between the V-line and the H-line, namely the influence

20 caused by the direction of the mask pattern relative to the projection vector in principle, without depending on the correction of the mask pattern, for example. Namely the present invention is to propose an exposure method capable of improving margin difference of the resolution

25 in the transferred image without introducing misalignment or deformation (distortion in pattern width) of the transferred image, a mask fabrication method, and a fabrication method of a semiconductor device.
[0014]

30 [Means for solving the problem]

The present invention is made to attain the above-

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mentioned object. Namely, the present invention is an exposure method for transferring a desired pattern on an exposure target using a reflective mask for an extreme ultra violet ray, which is characterized in that pattern

5 forming elements of a mask pattern corresponding to the above-mentioned desired pattern are divided with regard to respective direction relative to the projection vector of the extreme ultra violet ray and a set of reflective mask patterns each having only the pattern forming

10 elements of the same direction is provided, the transfer of the pattern on the exposure target is sequentially carried out by the irradiation and the reflection of the extreme ultra violet ray with regard to the reflective mask of respective direction, and, at the time when the

15 one reflective mask is changed to the other reflective mask, the other reflective mask and the exposure target are rotated relative to the projection vector so that the angle of the pattern forming elements of the other reflective mask and the projection vector is becomes

20 equal to the angle of the pattern forming elements of the one reflective mask and the projection vector.

[0015]

Further the present invention is a mask fabrication method that is made to attain the above-mentioned object.

25 Namely, the present invention is a fabrication method for fabricating a reflective mask to be used for transferring a desired pattern on an exposure target by reflecting an extreme ultra violet ray, which is characterized in that pattern forming elements of a mask pattern corresponding

30 to the above-mentioned desired pattern are divided with regard to respective direction relative to the projection

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vector of the extreme ultra violet ray, and a set of
reflective mask patterns each having only the pattern
forming elements of the same direction is provided. With
regard to respective reflective mask, each reflective
mask and the above-mentioned exposure target are rotated
relative to the projection vector so that the angle of
each of reflective mask and the projection vector is
always the same.

[0016]

Further the present invention is a fabrication
method of a semiconductor device that is made to attain
the above-mentioned object. Namely, the present
invention is a fabrication method of a semiconductor
device including a lithography process for transferring a
desired pattern on an exposure target by using a
reflective mask for an extreme ultra violet ray, which is
characterized in that pattern forming elements of a mask
pattern corresponding to the above-mentioned desired
pattern are divided with regard to respective direction
relative to the projection vector of the extreme ultra
violet ray and a set of reflective mask patterns each
having only the pattern forming elements of the same
direction is provided, the projection of the pattern on
the exposure target is sequentially carried out by the
irradiation and the reflection of the extreme ultra
violet ray with regard to the reflective mask of
respective direction, and, at the time when the one
reflective mask is changed to the other reflective mask,
the other reflective mask and the exposure target are
rotated relative to the projection vector so that the
angle of the pattern forming elements of the other

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reflective mask and the projection vector is becomes
equal to the angle of the pattern forming elements of the
one reflective mask and the projection vector.
[0017]

5   According to the exposure method, the mask
fabrication method, and the fabrication method of a
semiconductor device according to the above-mentioned
procedures, the mask patterns corresponding to a desired
pattern to be formed on an exposure target are divided
10   into V-line pattern forming elements and H-line pattern
forming elements with regard to respective direction, and
a pair of reflective mask patterns each corresponding to
respective direction is provided. Then, when the one
reflective mask is changed to the other reflective mask,
15   the other reflective mask and the exposure target are
rotated. Thereby, the angle of the pattern forming
elements of the respective mask and the projection vector
becomes always the same. Accordingly, even in the case
of the extreme ultra violet ray incident askew on the
20   reflective mask, there is no possibility of causing the
difference in the width of the transferred pattern
depending on the angle between the pattern forming
elements and the projection vector.
[0018]

25   [Practical form for Implementing the Invention]
       Hereinafter, an exposure method, a mask fabrication
method, a fabrication method of a semiconductor device,
and an exposure apparatus according to the present
invention will be described with reference to the
30   drawings. However, only the difference from a
conventional one is explained, and explanations for the

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configuration of an exposure apparatus which is similar
to the conventional one (see Fig. 3), and the
configuration of a reflective mask itself (see Fig. 4)
are omitted here.

5   [0019]

Fig. 1 is an explanatory view showing a brief
overview of an exposure method according to the present
invention. In a lithography process that is one of
processes for fabricating a semiconductor device, the
10   exposure method explained here is applied to the transfer
of an LSI pattern necessary for configuring the
semiconductor device on a wafer as an exposure target.
In more detail, this exposure method is applied, while
using a reflective mask for an EUV ray (wave-length =
15   13.5 nm, for example) to transfer a mask pattern formed
on the refection type mask on the wafer, thereby forming
the LSI pattern on the wafer.

[0020]

The mask pattern at this time includes pattern
20   forming elements 11a of a V-line extending in a parallel
direction relative to a direction of a projection vector
of a skewed incident EUV ray as shown in Fig. 1(a), and
pattern forming elements 11b of an H-line extending in a
vertical direction relative to the projection vector. In
25   order to transfer such mask pattern on a wafer, a
reflective mask is prepared (formed) by the procedures as
described below.

[0021]

Fig. 2 is a flowchart showing a flow of procedures
30   of a mask fabrication method according to the present
invention. As shown in the figure, when forming the

pattern of the reflective mask in the present embodiment,
input design data (data for whole pattern) are acquired
for the mask pattern corresponding to the LSI pattern to
be formed on a wafer (Step 101, hereinafter, step is
5   abbreviated to "S"). As the input design data, CAD
(Computer Aided Design) data may correspond to them, for
example. Then, the input design data are divided into V-
line data corresponding to the pattern forming elements
11a of the V-line, and H-line data corresponding to the
10   pattern forming elements 11b of the H-line.
[0022]

       To be more specific, with regard to the input design
data, a desired size in X-direction is erased in
accordance with over-size and under-size of only for an X
15   direction (S102), the graphic data only for the X
direction are extracted (S103). In this case, a
coordinate space on the input design data is consistent
with a coordinate space upon exposure. Accordingly, the
graphic data extending in the X direction correspond to
20   the H-line data, and the graphic data extending in the Y
direction (that is, the operating direction of the
exposure apparatus) correspond to the V-line data. After
the graphic data only for the X direction are extracted,
then the graphic data only for the X direction are
25   subtracted from the input design data (S104), and the
rest of the graphic data are extracted therefrom (S105).
These rest of the graphic data are to correspond to the
graphic data extending in the Y direction, namely, the V-
line data. As described above, in a case of forming such
30   reflective mask, it is necessary to divide the input
design data for the mask pattern into the V-line data and

the H-line data relative to respective direction with regard to the direction of the projection vector of the EUV ray.

[0023]

5   Then, on the basis of the divided V-line data and H-line data, as shown in Fig. 1(b), a V-line mask 12a having a mask pattern consisting only of the pattern forming elements 11a for the V-line and an H-line mask 12b having a mask pattern consisting only of the pattern

10   forming elements 11b for the H-line are respectively formed. Thus, the reflective masks 12a and 12b for respective direction are prepared.

[0024]

In this case, the V-line mask 12a and the H-line

15   mask 12b may be formed with a conventional method, so that the explanation thereof is omitted here. Further, regarding the division of the input design data into the divided V-line data and H-line data, it is not always necessary to carry out by the above-mentioned procedures,

20   and other graphic processing technology already known may be applied.

[0025]

After the V-line mask 12a and the H-line mask 12b are prepared, the mask pattern is at first transferred on

25   the wafer 8 using one of the two masks. Namely, the EUV ray is irradiated on one of the V-line mask 12a and the H-line mask 12b, and forms on the wafer 8 either the mask pattern consisting only of the pattern forming elements 11a for the V-line or an H-line mask 12b having the mask

30   pattern consisting only of the pattern forming elements 11b for the H-line by allowing the reflection light to

arrive on the wafer 8.

[0026]

    After one of the pattern image is transferred, the mask pattern of the other reflective mask 12a, or 12b is

5   transferred on the wafer 8. For example, in a case where the process for the exposure and transfer by using the V-line mask 12a has been completed, then the process for the exposure and transfer by using the H-line mask 12b is carried out. In this case, the relative position of the

10 H-line mask 12b which corresponds to the other reflective mask is rotated approximately by 90 degrees relative to the projection vector of the EUV ray. Further as shown in in Fig. 1(c), the relative position of the wafer 8 on which the pattern is to be transferred is also rotated

15 approximately by 90 degrees relative to the projection vector of the EUV ray.

[0027]

    Thereby, even if the irradiation target of the EUV ray is changed to the other reflective mask, namely to

20 the H-line mask 12b, an angle of the pattern forming elements 11b of the H-line mask 12b and the projection vector of the EUV ray becomes equal to an angle of the pattern forming elements 11a of the V-line mask 12b, which is either one of the reflective mask to which the

25 exposure and transfer process has been completed, and the projection vector of the EUV ray. Further, because the wafer 8 is also rotated by approximately 90 degrees, the transferred pattern image as desired is to be correctly formed on the wafer 8, even if the H-line mask 12b is

30 rotated by approximately 90 degrees when the mask is changed to the H-line mask 12b.

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[0028]

    As explained above, according to the present
embodiment, the V-line mask 12a and the H-line mask 12b
are provided or formed by dividing a mask pattern into

5   two regarding respective direction relative to the
projection vector of the EUV ray. Then, the exposure and
transfer processes by using respective reflective mask
12a and 12b are sequentially carried out. In this case,
exposures are to be carried out twice by rotating the

10   other mask and the wafer 8 at the time when the
reflective masks 12a and 12b are changed from the one to
the other. Therefore, even in the case where the EUV ray
is coming askew to respective reflective mask 12a and 12b,
the angle of the projection vector of the EUV ray and the

15   respective pattern forming elements 11a and 11b of the
respective reflective mask 12a and 12b is always the same.
Accordingly, no adverse effect due to the angle of the
projection vector and the pattern forming elements 11a
and 11b principally occurs even without depending on the

20   correction of the mask pattern, so that it is as much
possible to avoid occurrence of misalignment or
deformation (distortion of pattern width) of the
transferred image. As a result, it is able to prevent
the adverse effect of the direction of the mask pattern

25   to the resolution of the projected image.

[0029]

    Particularly, if, as explained in the above
mentioned embodiment, the exposure process is carried out
twice using the V-line mask 12a and the H-line mask 12b

30   in this order, and the extending directions of the
pattern forming elements 11a and 11b are aligned in the

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direction of the projection vector of the EUV ray, it becomes very effective in improving the resolution of the projected image on the wafer 8 even when the EUV ray is incoming askew.

[0030]

    It is noted that, in a case of forming an LSI pattern on the wafer 8, the pattern is composed of forming elements mainly extending in the directions of the V-line and the H-line, so that, as explained in the above mentioned embodiment, it is effective to expose twice using the V-line mask 11a and the H-line mask 11b from the perspective of the resolution, the efficiency of the process and the like. However, the present invention is not limited to expose twice using the V-line mask 11a and the H-line mask 11b. For example, if sequential exposures and relative positional rotations are carried out with regard to respective direction by providing respective reflective mask with regard to respective direction regarding the projection vector of the EUV ray, the exposure process may be carried out three times or more. That is, the above mentioned is one of embodiments of the present invention, and the scope of the present invention is not limited to this.

[0031]

[Effect of the Invention]

    As described above, according to the present invention, influence due to the direction of the mask pattern with regard to the projection vector can be prevented from occurring in principle depending on the exposure process divided into more than once, not depending on the mask pattern correction, for example.

20

Accordingly, even in the case of the extreme ultra violet ray incoming askew with regard to each reflective mask, the margin difference of the resolution of the transferred image can be improved more than a

5 conventional case without introducing misalignment or deformation (distortion of pattern width) of the transferred image.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

10   Fig. 1 is an explanatory view showing a brief overview of an exposure method according to the present invention, in which (a), (b), and (c) show procedures of the exposure method.

[Fig. 2]

15   Fig. 2 is a flowchart showing a flow of procedures of a mask fabrication method according to the present invention.

[Fig. 3]

    Fig. 3 is an explanatory view showing an example of

20 an exposure apparatus constituting a reflection type projection optical system.

[Fig. 4]

    Fig. 4 is a perspective view showing one structural example of a reflective mask used in the exposure

25 apparatus in Fig. 3.

[Fig. 5]

    Fig. 5 is a conceptual diagram for explaining a direction of a mask.

[Fig. 6]

30   Fig. 6 is an explanatory view for showing one specific example obtained by simulating difference of a

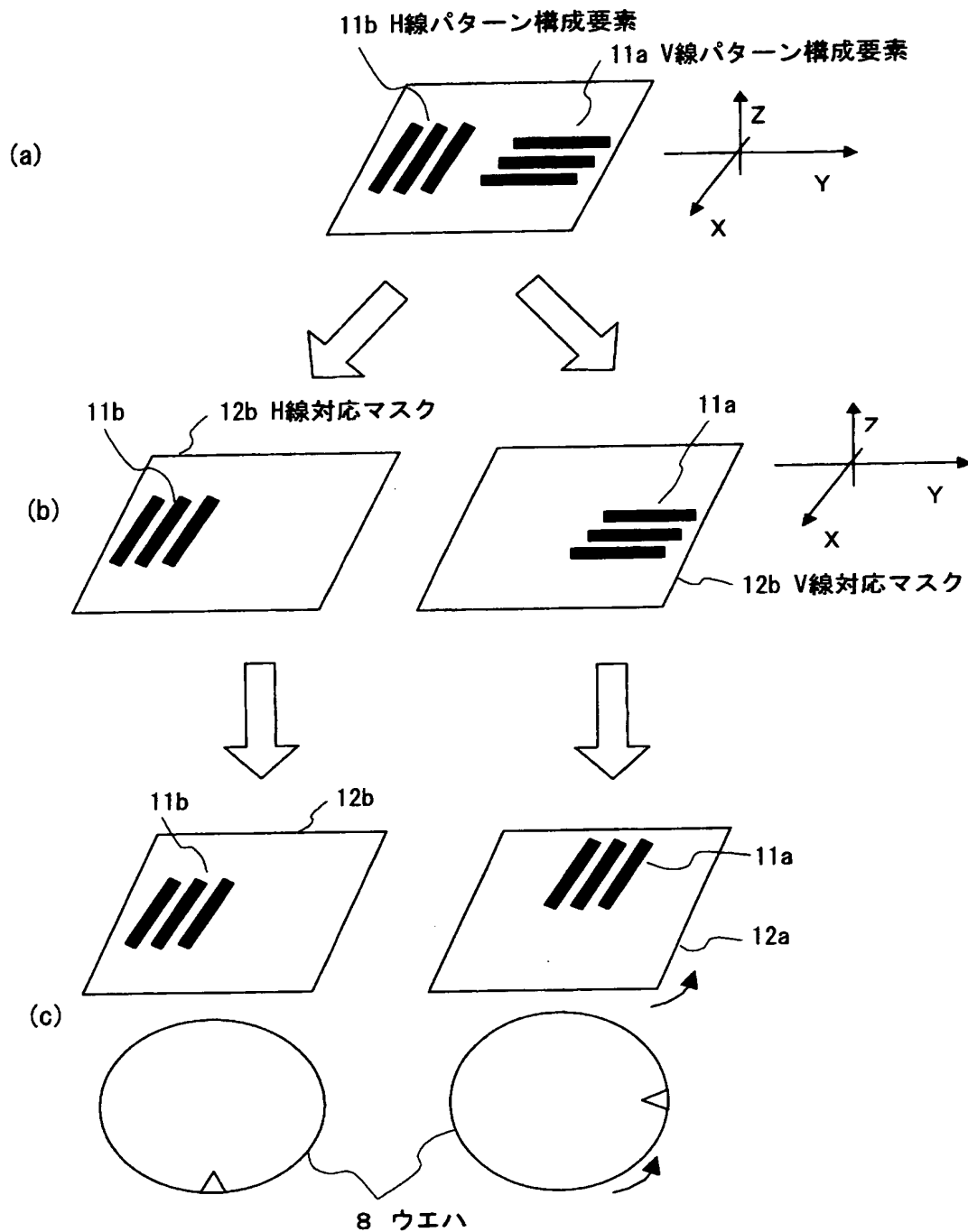pattern width of a V-line and an H-line after transfer in a case of an extreme ultra violet ray incident askew.

[Description of Reference Numerals]

8...wafer, 11a...pattern forming element of V-line, 11b...pattern forming element of H-line, 12a...V-line mask, 12b...H-line mask
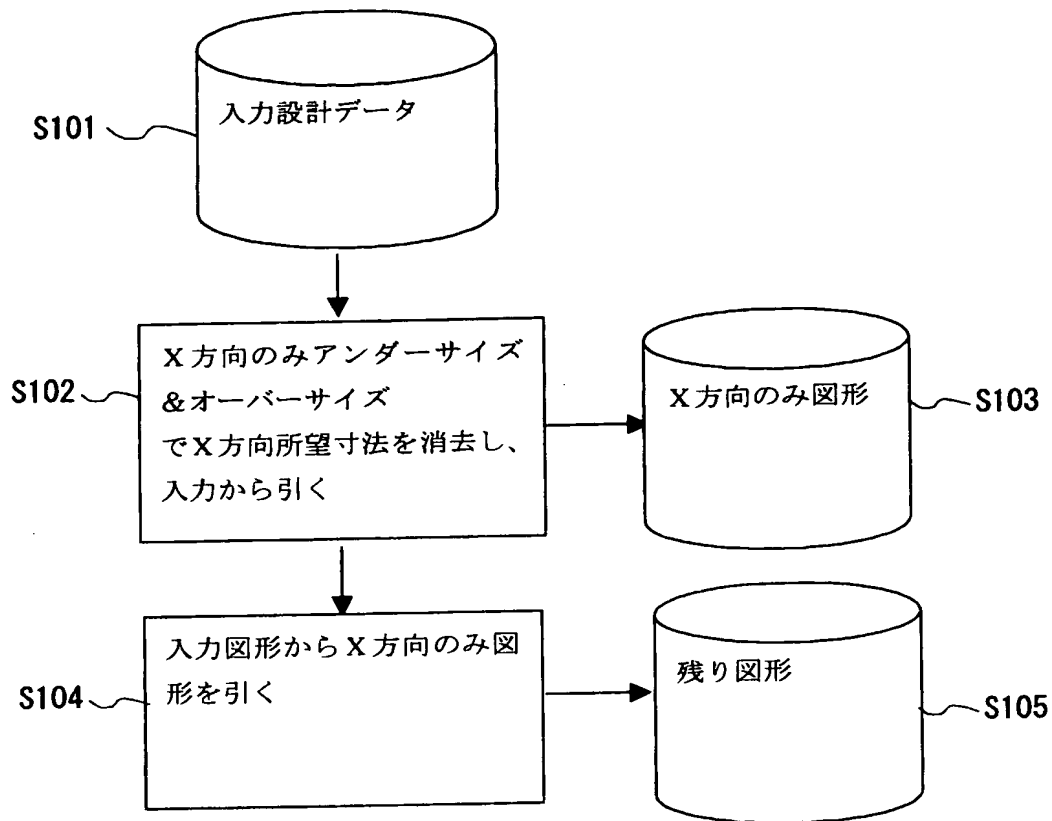
[Name of the Document]

[Drawings]

[Fig. 1]

(a)

11b H-LINE PATTERN FORMING ELEMENT

11a V-line pattern forming element

(b)

12b H-LINE MASK

12a V-LINE MASK

(c)

8   wafer

[Fig. 2]

S101   INPUT DESIGN DATA

S102   SUBTRACT FROM INPUT DATA BY ERASING DESIRED
SIZE DATA IN THE X DIRECTION WITH UNDER-SIZE AND OVER-
SIZE ONLY IN THE X DIRECTION

S103   GRAPHIC DATA ONLY IN THE X DIRECTION

S104   SUBTRACT GRAPHIC DATA ONLY IN THE X DIRECTION
FROM INPUT GRAPHIC DATA

S105   REST OF GRAPHIC DATA

[Fig. 3]

[Fig. 4]

ＥＵＶ光   EUV RAY

入射角Θ   INCIDENT ANGLE θ

[Fig. 5]

走査方向   SCANNING DIRECTION

ＥＵＶ光   EUV RAY

[Fig. 6]

ＶＨ線のＣＤフォーカスカーブ

              CD FOCUS CURVE FOR V-LINE AND H-LINE
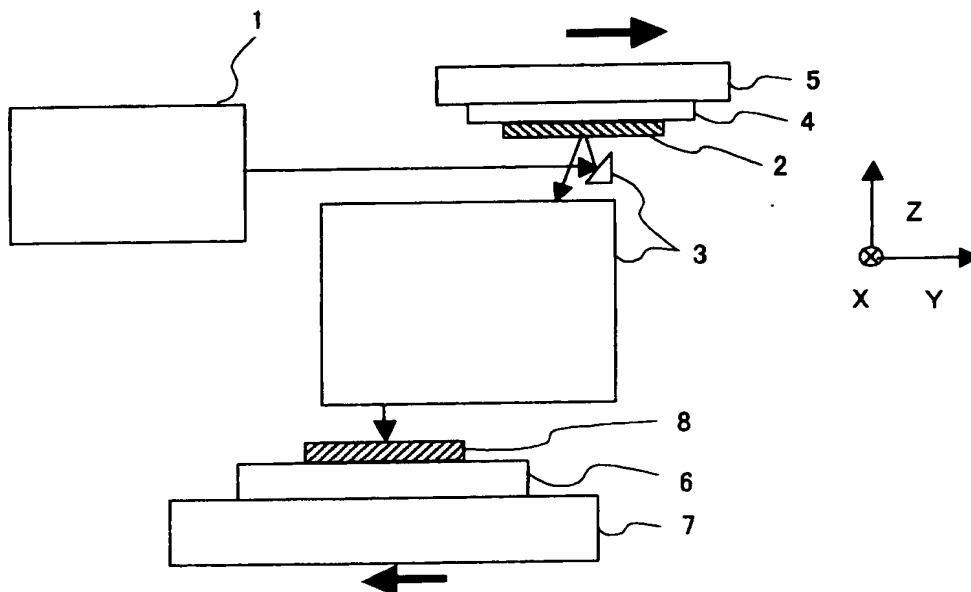
入射角度   INCIDENT ANGLE
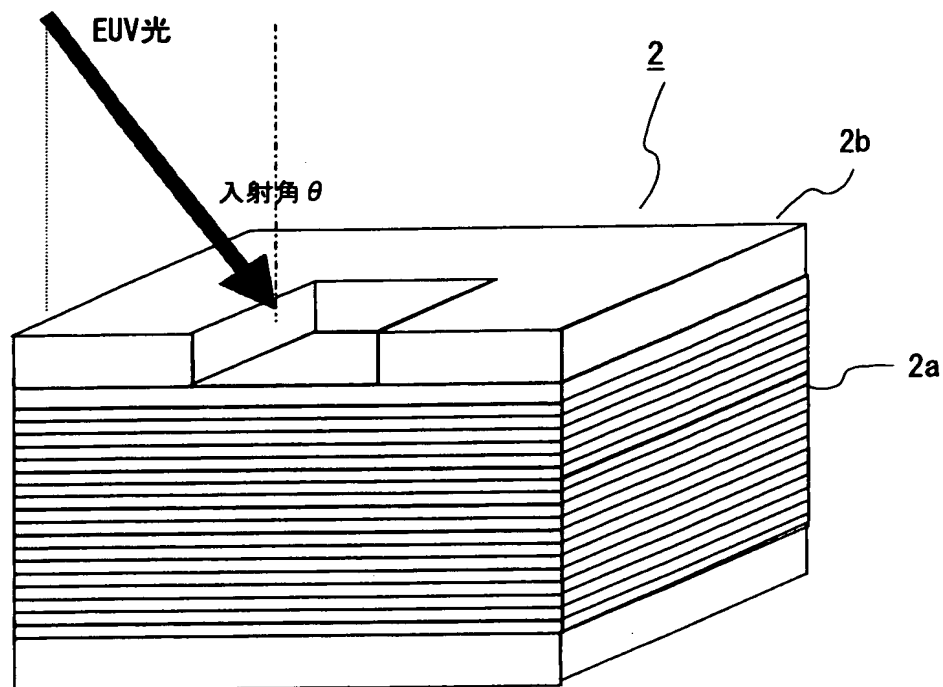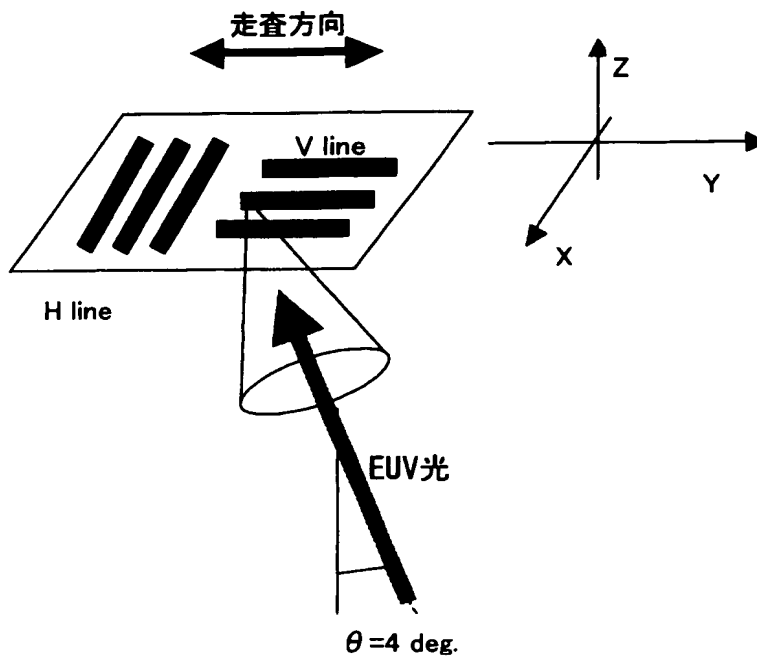
1

【書類名】　図面
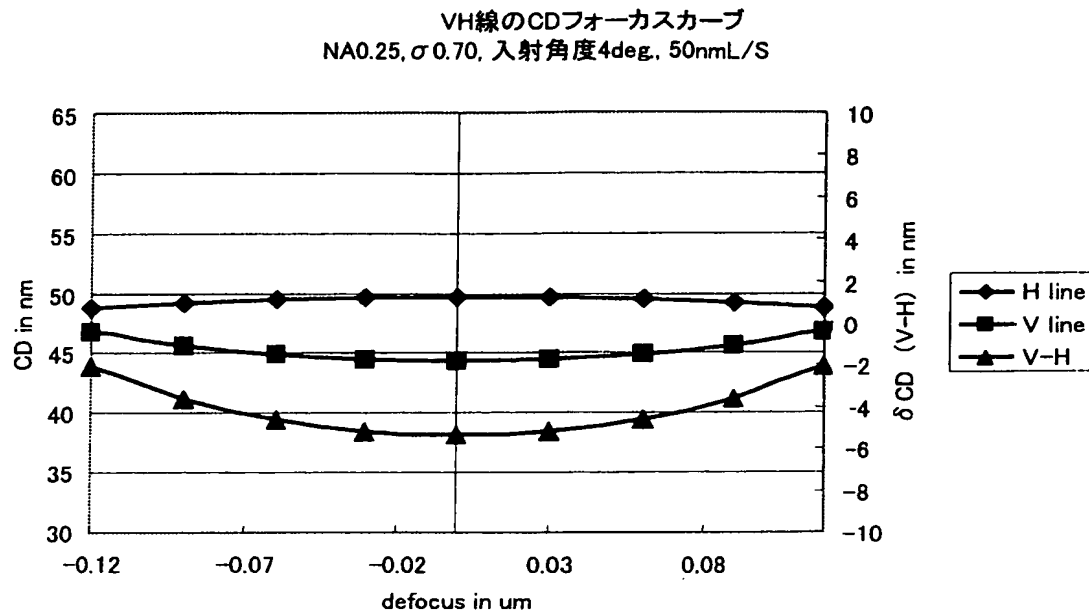
【図1】

【図2】

【図3】

【図4】

EUV光

入射角 θ

2

2b

2a

【図5】

【図6】

VH線のCDフォーカスカーブ
NA0.25, σ0.70, 入射角度4deg, 50nmL/S

[Name of the Document]

ABSTRACT OF THE DISCLOSURE

[Abstract]

[Object]

In a lithography process, even in a case of an extreme ultra violet ray incident askew with regard to a reflective mask, occurrence of misalignment or deformation (distortion in pattern width) of a transferred image due to the direction of a mask pattern is avoided.

[Solution means]

Pattern forming elements 11a, 11b of a mask pattern are divided relative to directions of a projection vector of an extreme ultra violet ray, pattern transfer on an exposure target 8 is sequentially carried out using reflective masks 12a, 12b of respective direction composed only of pattern forming element group of the same direction, and, at the time when one reflective mask is changed to the other reflective mask, the other reflective mask and the exposure target are rotated so that an angle of the pattern forming elements of the other reflective mask and the projection vector becomes equal to an angle of the pattern forming elements of the one reflective mask and the projection vector.

[Selected Drawing]

Fig. 1